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The influence of memory latency and bandwidth on system performance

Slow application response can cause an end user to experience anything from a frustrating delay to a missed opportunity in a split-second financial transaction. Part of the problem could be that the application is not optimized for the server, or vice versa. One example is when a single-threaded application runs on a server with multi-core processors (See "Multi-core Technology" in Volume 7, Number 6 of the *ISS Technology Update*).

Alternatively, slow application response can occur while the processor is waiting for data from system memory, commonly referred to as memory latency. Memory latency is the time it takes for non-cached data to be retrieved from synchronous dynamic random access memory (SDRAM) after a READ request from the processor. This time is measured in bus clock cycles, with each clock cycle lasting a few billionths of a second, or nanoseconds. Although latency is measured in nanoseconds, it has a relatively significant impact on system performance. In fact, system designers have found that a two percent reduction in memory latency can cause a one percent improvement in system performance for some database applications. Conversely, excessive latency can cause the processor to stall as it waits for data, bringing the entire system to a crawl.

As shown in Figure 1, the total response time consists of flight time of the read request on the front side bus (FSB), propagation delay through the memory controller, flight time on the memory bus, response time of the SDRAM, and the time it takes for data to travel back to the processor. Flight time is the time it takes for commands and data to travel along the FSB and memory bus. Flight time is affected by the operating frequency of the buses.

The response time of the SDRAM is the delay, in clock cycles, while retrieving the data and driving it to the SDRAM pins on the bus. This delay is also referred to as CAS latency (see right column: "SDRAM operation").

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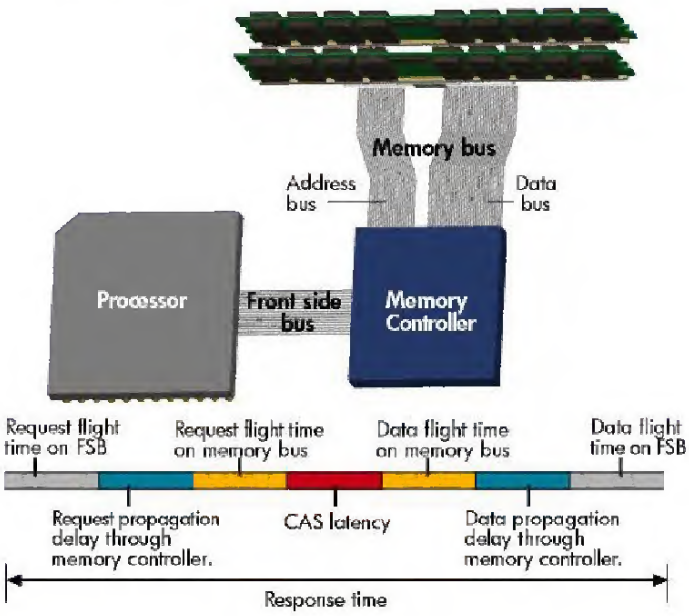
Figure 1-1. Response time of the processor's request for data



Memory bandwidth is the theoretical maximum rate (bytes per second) that data can be read from or stored by SDRAM. For standard SDRAM, the bandwidth is calculated by multiplying the width of the memory bus (channel), by the bus frequency in megahertz (in MHz), by the number of channels. For example, the bandwidth of a dual-channel, 64-bit (8-byte), 400-MHz memory bus is 8 bytes × 400 MHz × 2 channels or 6.4 GB/s. This bandwidth is doubled for Double Data Rate (DDR) SDRAM.

Some applications, such as high performance computing (HPC), 3D graphics, and multimedia, are sensitive to memory bandwidth because the data is seldom cached. A memory-intensive application running on a server with multi-core processors can saturate the shared memory bus, resulting in degraded performance for all the jobs running on that processor.

Other applications, such as databases and online transaction processing (OLTP) are more latency sensitive. Database traffic is sensitive to latency because the delay can represent a much higher percentage of the total response time. For OLTP applications, lower latency means more transactions can be processed.

Reducing latency can have a greater impact on performance than increasing the bandwidth because lower latency decreases the processor wait time. On the other hand, high latency can negate the performance benefit of increasing the memory bandwidth.

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Meet the Expert—Vincent Nguyen

Vincent Nguyen is an ISS Technalagist with aver 20 years at Campaq/HP. Vincent began as a technician and advanced ta became a system architecture expert an single- and dual-sacket Intel®-based PraLiant servers, which happen ta be the best-selling HP servers. As a system architect, he is familiar with all aspects af the design and inventian pracess. He is knawn far being very "hands-an" and he cansults in numeraus areas, including pawer management, security, and RAS (reliability, availability, and scalability).

Accarding ta Gene Freeman, Vincent's manager, many af Vincent's innavatians have became industry-standard features in Intel Architeture (IA) x86 and IA-64 bit server segments. Vincent has created several methadalagies that have resulted in lawer praduct develapment and manufacturing casts. He is alsa an active vaice within the design centers and cammanality care teams, which ensure that the variaus platfarms have aptimized, balanced architectures. Gene says that Vincent's innavatians are inspired by the knawledge he gains abaut custamers thraugh Tech Taurs and Tech Exchanges. After his inventian is appraved by ane af the design teams, Vincent helps ta wark thraugh any technalagical abstacles ta ensure a timely praduct release.

Vincent co-authared the 2004 Techcan paper, "Expanding Memary RASUM Features in ISS servers." The paper was selected fram mare than 1500 abstracts acrass technical cammunities af all HP Business Units.

Vincent says that his favarite habbies are traveling and learning abaut ather cultures. These have given him a wider perspective, which influences his wark by making him apen minded ta ideas fram athers. Gene paints aut that "Vincent firmly believes in teamwark and in sharing infarmatian amang peers. He has a simple philasaphy that na ane team member knaws everything."

Vincent and his wife, Melanie, have three beautiful daughters ages 20, 18, and 8. Belaw are excerpts fram an interview with Vincent. As evidenced by his respanses, he is a man af few wards, but many patents. The patents are listed an the right and the patents filed are listed an the fallawing page.

Why did you decide to become an engineer?

There was na reasan in particular. The trend at the time was taward engineering.

What are your favorite inventions?

The system BIOS baat-black and an-line spare/hat-plug memary inventians are my favarites. They have became industry-standard features taday. I develaped a pratatype baard that implemented a baat black feature ta prevent the tatal lass af ROM cade if a catastraphic event accurred during a ROM upgrade. I alsa develaped the first an-line spare and hat plug/redundant memary cantraller in the PC server industry. I designed discrete lagic an the PraLiant DL380 G2 server ta detect a faulty DIMM and then fail aver ta an an-line spare memary DIMM. I alsa designed a memary baard that implemented the hat plug cancept ta interface with the RCC Champian 1.0 chipset. I alsa wrate the ROM cade and warked with several NT develapers ta madify the OS ta suppart "Hat Add/Replace" memary when a DIMM was inserted ar replaced.

Name: Vincent Nguyen
Title: ISS Technologist
Years at HP: 20
Education:

- University af Haustan Bachelar af Science, Electrical Engineering, 1992

U.S. Patents:

- Patent #7107493: System and method for testing memory errors in a computer system. Nguyen, V., Depew, K.; 9/12/06
- Patent #7035953: Computer system architecture with hot pluggable memory board. Krontz, J., Depew, K., Nguyen, J., Heinrich, D., Engler, D., Nguyen, V., Dow, R., Kidwai, O.; 4/25/06
- Patent #6487623: Replacement, upgrade and/or addition of hot-pluggable components in a computer. Emerson, T., Nguyen, V., Michels, P., Clohset, S.; 11/26/02
- Patent #6401157: Hot-pluggable component detection logic. Nguyen, V., Emerson, T.; 6/04/02
- Patent #6055582: SCSI duplex ready backplane for selectively enabling SCSI simplex and duplex modes based on indication of desired SCSI mode ; Pascarella, R., Nguyen, V.; 4/25/00
- Patent #5867676: Reset circuit for a peripheral component interconnect bus. Nguyen, V., Brownell, P.; 2/02/99

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How much customer input goes into the design of your products?

I value and seriously consider customer input and feedback, and I try to directly implement them into HP products. After all, it's a solution set that we have to deliver to our customers.

What must HP do to remain the leader in industry-standard servers?

Innovation is at the top of my list since product quality, reliability, and the right feature set are a given.

U.S. Patents (filed):

- #7327612: Method and apparatus for providing the proper voltage to memory. Nguyen, V., Bacchus, R.; 02/05/08
- #7299331: Enhanced CPU RASUM feature in ISS server. Depew, K., Nguyen, V., Heinrich, D., Engler, D.; 11/20/07
- #7246190: Method and Apparatus for providing a bus in a computer system. Nguyen, V., Venugopal, R.; 07/17/07
- #7234081: Intelligent software controlled test DIMM. Nguyen, V., Vi Lu, Krontz, J.; 11/20/07

Soft memory errors caused by natural phenomena

All dynamic random access memory (DRAM) chips are inherently susceptible to soft memory errors. A DRAM chip is an integrated circuit that contains millions of memory cells. Each memory cell contains an extremely small transistor and capacitor that can store an electrical charge. When a memory cell is accessed during a read operation, an electrically charged capacitor represents a "1" data bit. An uncharged capacitor represents a "0" data bit.

The charge (number of electrons) stored by a capacitor is proportional to its size, or storage area. The capacitor's charge is also directly proportional to the memory device's operating voltage. Over the years, improvements in DRAM storage density have resulted in smaller memory cells and lower operating voltage—from 5 volts originally to 1.8 volts today. The lower operating voltage allows memory to run faster and consume less power. However, as the voltage is reduced, the logical function of the memory is more susceptible to errors. In addition, as memory cells become smaller, the storage area and charge of a capacitor that represents a "1" data bit shrinks proportionately. The reduced charge makes the memory cell more sensitive to natural and man-made phenomena that can inadvertently change the charge and, therefore, the data stored in a memory cell. If the value of a data bit is changed and not corrected, the error can cause an application to crash or cause it to pass on bad data.

Memory errors generally fall into two categories—hard errors and soft errors. A hard error consistently returns incorrect results, indicating a silicon defect. For example, a memory cell may be stuck so that it always returns a "0" bit, even when a "1" bit is written to it. On the other hand, soft errors are more prevalent than hard errors. Soft errors occur randomly when an electrical disturbance near a memory cell alters the charge on the capacitor. A soft error does not indicate a problem with a memory device because once the data is corrected, the same error does not reoccur. Today's servers with large memory capacities typically experience several soft memory errors annually. Scientific research has revealed that the cause of most soft errors is literally out of this world (see "Cosmic particles" sidebar).

Cosmic particles

Highly energized cosmic particles (neutrons or protons) that originate from solar and extra-solar sources can have enough energy to penetrate earth's atmosphere. When cosmic particles collide with air molecules, the collisions produce multiple lower energy particles that result in cascade collisions or "showers." These particles penetrate most matter. They can randomly collide with an integrated circuit (IC) and fragment silicon nuclei, producing alpha-particles and other secondary particles that can travel in all directions. If one of these particles travels near a p-n junction in the chip, it can cause a signal to change voltage and, consequently, a data bit to change value.

The collision of cosmic particles with a memory chip can generate hundreds of trillions of electrons and can "flip" the value of a bit in a nearby memory cell, resulting in a single bit error. As memory cell density increases, more memory cells can be affected by a single particle collision. Plus, as voltage is lowered, the logical operation of the memory can be affected. Using error checking and correcting (ECC) algorithms can detect and correct single bit errors; however, some particle collisions can cascade to affect multiple bits. Fortunately, HP servers—with the exception of some single processor servers—feature Advanced ECC, which can reliably correct multi-bit errors when they occur within a single DRAM chip.

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As DRAM storage density increases and operating voltage decreases, the frequency of cosmic-particle-induced soft errors may increase. DRAM manufacturers are trying to lessen the likelihood of cosmic particle collisions by changing the memory cell geometry.[1] No current efforts have successfully eliminated cosmic-particle-induced soft errors; however, a method has been invented to detect them. In December 2007, Intel was granted U.S. patent 7166847, System with response to cosmic ray detection, for a device that can detect cosmic particle events in integrated circuit chips. If an event is detected, its location could be used to reload the correct data in nearby memory cells.

Spotlight: HP Microsoft Solutions Lab benefits customers, partners, and resellers

Focus on Microsoft solutions for HP servers

HP has various on-site labs for conducting research and development (R&D). This article highlights the Microsoft Solutions Lab, which is responsible for characterizing, sizing, and testing Microsoft applications on HP Proliant servers, as well as on StorageWorks and Integrity servers. The ten solutions engineers who comprise the Microsoft Internet Business Solutions group at HP (a part of the HP ESS Software division) focus their efforts on developing best practices for deployment and capacity planning purposes.

Review and test solutions

Essentially an R&D team, the lab members routinely review and test Microsoft-related solutions before they are applied in the field. The solutions involve Windows network architectures and recommended configurations as well as application integration. As needed, Microsoft technicians are brought into the lab to incorporate their expertise on specific projects.

Figure 2-1. Views of the HP Microsoft Solutions Lab.

[1] Ziegler, J. E., Nelson, M. E., Shell, J. D., et al. "Cosmic Ray Soft Error Rates of 16-Mb DRAM Memory Chips." IEEE Journal of Solid-State Circuits, V. 33, N. 2, pp. 246-252, February 1998.

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Proof of concept

The lab also performs proof-of-concept testing for Microsoft server applications on the latest HP server products (for example, the Microsoft Hyper-V server). In such cases, both performance and characterization testing are typically part of the lab's job. Tests are performed in different server environments to ensure compatibility. Also, the lab develops and shares recommended sizing and deployment best practices information through an online sizer and white papers on the HP Web site (see "Additional resources" below).

Practical benefits

Ongoing lab work contributes to the HP knowledge base, providing practical benefits to partners, customers, and resellers, as well as HP services personnel and server development engineers. According to Al Jimenez, solutions engineering manager, "We look out for our customers by testing real-world customer scenarios on HP ProLiant (and other) servers using Microsoft technologies." Visitors are welcome in the lab if they want to see the process for themselves.

Current lob projects

Currently, the lab's documentation projects include developing a number of technical white papers:

- Microsoft Windows Server 2008 IIS 7.0 Web Server
- Microsoft Windows Server 2008 Hyper-V Server virtualization on HP BladeSystem and ProLiant Servers

In addition, the lab is busy with the following activities:

- characterizing Active Directory for an HP customer
- hosting a virtualized lab infrastructure for the HP Services organization
- providing an environment to test applications with the HP BladeSystem c7000 enclosure

Summory

The HP Microsoft Solutions Lab, one of HP's many labs, has the key function of testing Microsoft products and solutions in conjunction with HP server technologies. The lab generates best practices, along with white papers and other helpful information ultimately posted online for both external and internal use.

Additional resources

For additional information on the topics discussed in this article, visit the following links:

Resource	URL
Solution sizers*	http://www.hp.com/solutions/activeanswers/sizers
Technicol white popers	http://www.hp.com/solutions/activeanswers

*Note: HP Possport registrotion is needed to occess this informotion.

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Overview of Microsoft® Windows® Essential Server Solutions

Windows Essential Server Solution products improve productivity and reduce complexity for small and midsize businesses. Microsoft® Windows® Small Business Server 2008 (SBS) provides an out-of-the-box solution for small business customers. Microsoft Windows Essential Business Server 2008 (EBS) provides an integrated server and management solution for mid-size networks.

IMPORTANT
The current releases of Windows SBS and Windows EBS are beta releases; therefore, they are not recommended for production servers.

Beta releases of these solutions are now available. Trial versions are available on the Microsoft website:

- Windows Small Business Server 2008: http://technet.microsoft.com/en-us/evalcenter/cc184870.aspx.
- Windows Essential Business Server 2008: www.microsoft.com/windowsserver/essential/ebs/default.mspx.

Introduction to Windows Small Business Server 2008

Windows Small Business Server 2008 (Figure 3-1) offers a complete solution designed for small businesses with 5 to 75 desktop clients. Windows SBS builds upon earlier versions of the small business platform. It offers easier setup and installation, simplified management, and improved network-wide security features for the small business customer.

NOTE
Windows SBS is only available as a 64-bit operating system; a 64-bit processor is required to install and use Windows SBS.

Windows SBS is available in the following editions:

- **Standard Edition**—Windows Small Business Server 2008 Standard Edition runs on one hardware server.
- **Premium Edition**—Windows Small Business Server 2008 Premium Edition runs on two hardware servers, with the second server running Microsoft SQL Server 2008 Standard Edition for line-of-business applications.

NOTE
Line-of-business applications are computer applications that are specific for running a business, such as accounting, supply chain management, and resource planning applications.

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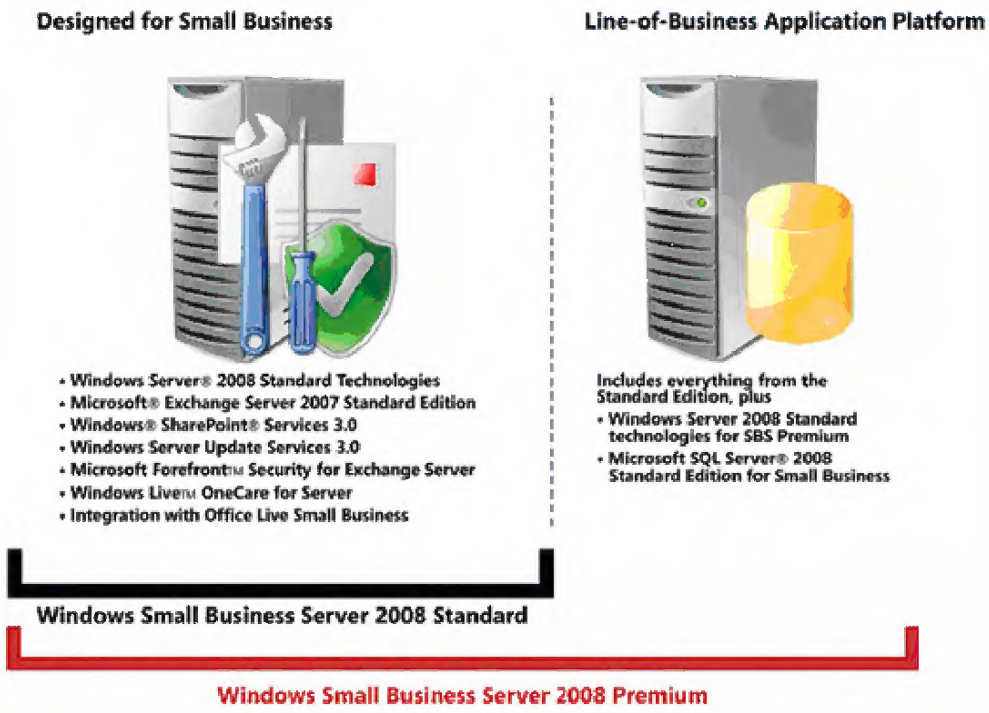
Figure 3-1. Windows SBS edition features


Designed for Small Business
Line-of-Business Application Platform
• Windows Server® 2008 Standard Technologies
• Microsoft® Exchange Server 2007 Standard Edition
• Windows® SharePoint® Services 3.0
• Windows Server Update Services 3.0
• Microsoft Forefront™ Security for Exchange Server
• Windows Live™ OneCare for Server
• Integration with Office Live Small Business
Includes everything from the Standard Edition, plus
• Windows Server 2008 Standard technologies for SBS Premium
• Microsoft SQL Server® 2008 Standard Edition for Small Business
Windows Small Business Server 2008 Standard
Windows Small Business Server 2008 Premium

Benefits of Windows SBS

Small businesses will benefit from the following features:

- **Simplified installation and configuration**—Multiple product installations are integrated into a single, easy-to-use deployment wizard reducing installation time and complexity.
- **Simplified management**—A streamlined management console presents the administrator with relevant system information and a matching set of tasks, creating a simple, efficient, and effective process that even a non-technical person can perform.
- **Enhanced Business Productivity**—Advanced collaboration tools like Remote Web Workplace and SharePoint Services provide Web site administration and security allowing small businesses to remain competitive with their larger counterparts.
- **Network-wide Protection**—Leading-edge protection technologies are integrated to provide real-time network status and protect small business networks and valuable data.

Introduction to Windows Essential Business Server 2008

Windows Essential Business Server 2008 (Figure 2) is designed for the mid-size customer (up to 250 clients). Windows EBS is a multi-server solution that provides the essential technology needed for a highly secure and reliable infrastructure. Windows EBS has an integrated setup with out-of-the-box configuration settings based on best practices for midsized businesses making it easy to install and maintain while providing optimal protection and a new management experience.

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NOTE
Windows EBS is derived from Windows Server 2008 x64 Standard Edition. Microsoft does not plan to release a 32-bit version of Windows EBS.

Windows EBS is available in the following editions:

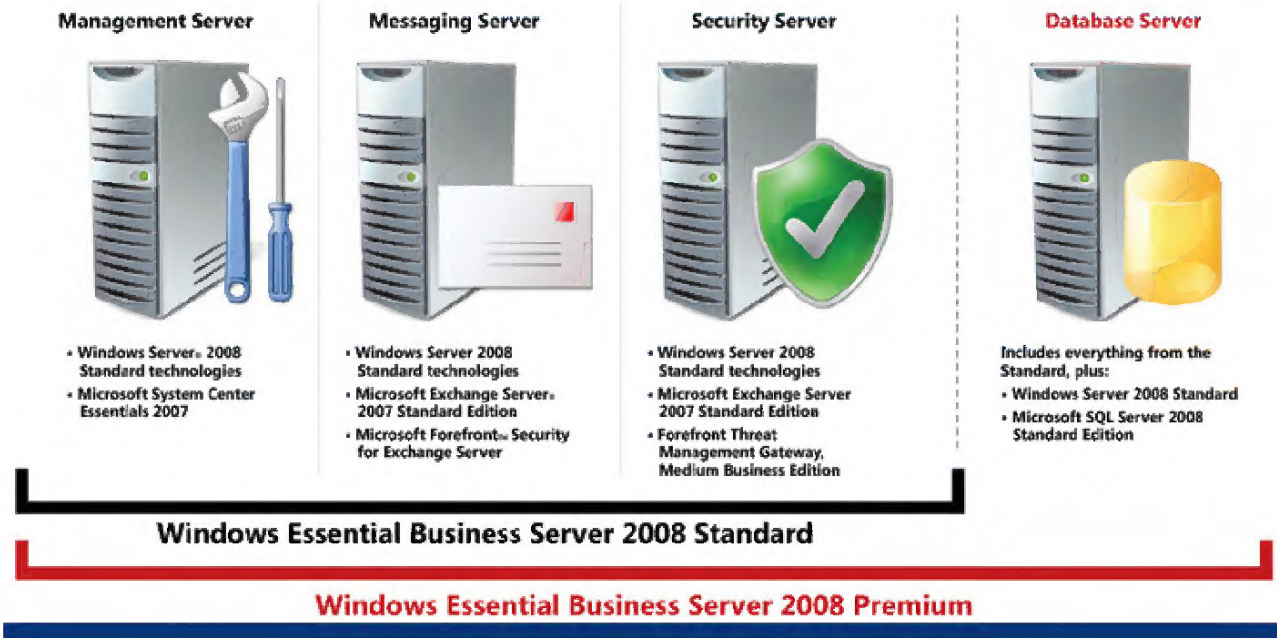
- Standard Edition, which requires a three-server deployment
- Premium Edition, which requires a four-server deployment

Windows EBS Standard Edition is a network of three physical servers:

- Management Server
- Messaging Server
- Security Server

Windows EBS Premium Edition adds a Database Server to the network.

Figure 3-2. Windows EBS server infrastructure


Management Server
• Windows Server® 2008 Standard technologies
• Microsoft System Center Essentials 2007
Messaging Server
• Windows Server 2008 Standard technologies
• Microsoft Exchange Server® 2007 Standard Edition
• Microsoft Forefront™ Security for Exchange Server
Security Server
• Windows Server 2008 Standard technologies
• Microsoft Exchange Server 2007 Standard Edition
• Forefront Threat Management Gateway, Medium Business Edition
Database Server
Includes everything from the Standard, plus:
• Windows Server 2008 Standard
• Microsoft SQL Server 2008 Standard Edition
Windows Essential Business Server 2008 Standard
Windows Essential Business Server 2008 Premium

Benefits of Windows EBS

Mid-size businesses can benefit from the following features:

- **Simplified installation and configuration**—Windows EBS installs and licenses Windows Server 2008, Microsoft Exchange, and several other essential security and IT management products. This simplifies installations and quickly implements networks.
- **Simplified management**—From a central administration console, IT administrators can add users or review and respond to system alerts. This console provides a consistent interface from which to perform most management tasks.
- **Enhanced security**—The Windows EBS Security Server employs the latest Microsoft technologies to reduce network security risks and help block unwanted "spam."

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Additional resources

The following integration notes (and Web links) provide details for Windows Essential Server Solution products on HP ProLiant servers:

- Implementing Microsoft Windows Small Business Server 2008 Release Candidate 0 (RC0) on HP ProLiant servers integration note, http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01479108/c01479108.pdf
- Implementing Microsoft Windows Essential Business Server 2008 Release Candidate 0 (RC0) on HP ProLiant servers integration note, http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01467895/c01467895.pdf

These documents include some valuable information:

- Supported configurations of ProLiant servers
- Recommended system configuration and server platforms
- Supported software, storage options, and network adapters
- Procedures for new installations
- Known issues

For additional information on the topics discussed in this article, visit the following websites:

Resource	URL
Microsoft Windows Server 2008 website	www.microsoft.com/windowsserver2008/default.mspx
HP and Microsoft Frontline Partnership website	www.hp.com/go/microsoft
Windows Essential Server Solutions Family website	www.hp.com/go/winessentialfamily
Implementing Microsoft Windows Small Business Server 2008 Release Candidate 0 (RC0) on HP ProLiant servers integration note	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01479108/c01479108.pdf
Implementing Microsoft Windows Essential Business Server 2008 Release Candidate 0 (RC0) on HP ProLiant servers integration note	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01467895/c01467895.pdf
HP reference configuration for Microsoft Windows Essential Business Server on HP BladeSystem c3000 enclosure white paper	http://h71028.www7.hp.com/ERC/downloads/4AA1-8230ENW.pdf?jumpid=reg_R1002_USEN
HP ProLiant Support Pack for Microsoft Windows Server 2008 x64 Editions	http://h20000.www2.hp.com/bizsupport/TechSupport/SoftwareDescription.jsp?lang=en&cc=us&prodTypeId=15351&prodSeriesId=1121516&prodNameId=3288134&swEnvOID=4024&swLang=8&mode=2&taskId=135&swItem=MTX-e10998a3b61e464b958ffb8519

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Recently published industry standard server technology communications

Title	URL
"Integrating HP ProLiant Lights-Out processors with Microsoft® Active Directory" technology brief	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00190541/c00190541.pdf
"Integrated hypervisor virtualization technologies in HP BladeSystem ProLiant server blades and ProLiant servers" technology brief	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01518167/c01518167.pdf
"Implementing Microsoft Windows Server 2008 Hyper-V on HP ProLiant servers" integration note	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01516156/c01516156.pdf
"Integrating HP Insight Management WBEM Providers with HP System Insight Manager" integration note	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01509052/c01509052.pdf
"Implementing Novell NetWare 6.5 on HP ProLiant servers" integration note	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00257406/c00257406.pdf

Industry-standard server technical communications can be found at www.hp.com/servers/technology.

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